Activity 2

Disease Detectives

At a Glance

Focus: Students assume the roles of public health experts to investigate the cause of a mystery disease.

Major Concepts: A major cause of the emergence of new diseases is environ mental change (for example, human encroachment into wilderness areas and increased human traffic through previously isolated areas).

Objectives: After completing this activity, students will

- recognize the variety of evidence that epidemiologists must collect to determine the origin, infectious agent, and route of transmission of an infectious disease;
- be able to give examples of how an infectious agent can be transmitted to humans; and
- be able to explain how environmental changes can result in the emergence of infectious diseases.

Prerequisite Knowledge: Students should know that infectious diseases are diseases that result from the presence of an external agent or its products. Students should also know that antibodies are produced by the body in response to invasion by a foreign organism or molecule, and that the presence of particular antibodies indicates a previous encounter with the foreign agent that triggered their production. They should also understand that purified antibodies to a particular organism or molecule can be used to detect that organism or molecule in tissue samples from victims of an infectious disease.

Basic Science-Public Health Connection: This activity demonstrates how scien tists use ecological, biochemical, and medical research to investigate infectious disease outbreaks. The activity also illustrates how the results of such research can help stop epidemics and lead to public health recommendations and the development of drugs and vaccines to limit future epidemics of the disease.

Introduction

When local health care workers recognize a cluster of strange disease cases with similar characteristics, they bring it to the attention of national public health officers. Epidemiologists collect a variety of evidence including demographic evidence (such as geographic location, age and other defining characteristics of victims, and mortality rate), laboratory evidence from victims' tissues, and evi dence about environmental factors that might be involved. Their goal is to pro tect public health by identifying the disease as rapidly as possible and recom mending appropriate actions to prevent it from becoming an epidemic.

A recent example of the effectiveness of this strategy was the identification of hantavirus pulmonary syndrome (HPS) as an emerging disease. Cases of this

apparently new disease were first recognized in May 1993. Within four months, the infectious agent had been identified as a "new" variety of hantavirus, the reservoir of the virus had been determined to be deer mice, and the route of transmission (inhalation of viral particles from the rodents' feces and urine) had been deciphered. Strategies for avoiding contact with the virus were developed, and early diagnosis and support therapy were recommended to reduce mortal ity due to the disease.

Three "mystery diseases" (unnamed for the students, but based on HPS, Lyme disease, and Lassa fever) are the initial focus of this activity. HPS was first rec ognized in 1993; Lyme disease first came to the attention of public health work ers in 1975 as an unusual number of cases of juvenile rheumatoid arthritis in children in Lyme, Connecticut; and Lassa fever was first identified in an out-break in Nigeria in 1969. Cases of HPS were originally clustered in the Four Corners region of the U.S. Southwest, and the majority of cases to date have been found there. Lyme disease is the most commonly diagnosed tick-borne disease in the United States, with the majority of cases clustering in the north-east United States, although cases have occurred in 48 of the 50 states. Lassa fever outbreaks occur in west Africa.

Investigating these diseases leads students to recognize that all three of these new diseases "emerged" as a result of environmental changes and / or move ment of humans into areas inhabited by the organism that serves as reservoir for the pathogen. The two activities that follow, Activity 3, *Superbugs: An Evolving Concern*, and Activity 4, *Protecting the Herd*, help students understand two factors involved in the re-emergence of infectious diseases.

Materials and Preparation

You will need to prepare the following materials before conducting this activity:Ä

- blank transparenciesÄ
- Master 2.1, *Three Mysterious Diseases* (make 1 copy per student)Ä
- Master 2.2, *Documents from Physician's Investigation File* (make a classroom set)Ä
- Master 2.3, *Documents from Laboratory Scientist's Investigation File* (make a class-Ä room set)
- Master 2.4, *Documents from Field Researcher's Investigation File (make a classroom set)*

  To make investigation files, copy Masters 2.2, 2.3, and 2.4 and assemble them into file folders that you label "Physician's File," "Laboratory Scientist's File," and "Field Researcher's File." You may want to use a different colored folder for each type of file. Make enough sets of these files so that no more than three or four stu dents (one student from each of three or four different teams) study the docu ments in the file together. For example, for a class of 30 students (10 teams), pre-pare three sets of each type of file.

- Master 2.5, *Notes from the Physician's Investigation* (make 1 copy per team)
- Master 2.6, *Notes from the Laboratory Scientist's Investigation* (make 1 copy per team)
- Master 2.7, *Notes from the Field Researcher's Investigation* (make 1 copy per team)

- Master 2.8, *Mystery Disease 1 Final Report* (make 1 copy per team)
- Master 2.9, *Mystery Disease 2 Final Report* (make enough copies for half the teams)
- Master 2.10, *Mystery Disease 3 Final Report* (make enough copies for half the teams)
- Master 2.11, *Mystery Diseases Summary Table* (make 1 copy per student and 1 transparency)

Procedure

1. **Introduce the activity by asking students to suppose that a friend developed a strange rash and then a fever accompanied by severe vomiting and diarrhea. Their friend was hospitalized for a week before finally recovering. Then, they hear about a student in another class who had similar symptoms, and they learn that this student's cousin was also sick with fever, vomiting, and diarrhea. A few days later, they hear a television report about a strange illness affecting five students at a nearby high school. The symptoms described sound just like those experienced by their friend. Ask students to suggest questions they might ask about how to protect themselves from this illness. Write these questions on the board or a transparency.**

   If students ask, explain that the symptoms do not indicate a particular disease, but are used to get students thinking. Complete this step quickly, accepting and listing four or five reasonable questions from students, such as "Do all the sick people have the same disease?" "What is the cause of the disease?" and "Do the victims have anything in common that can tell us how the disease is transmitted?" It is impor tant to leave these questions on the board or the overhead projector so that students can refer to them as they complete the activity.

2. **Tell students that public health officers are responsible for answering these types of questions when a cluster of unusual cases of disease occurs. Explain that in this activity students will follow in the footsteps of public health officers to answer some of the questions they have listed about a mystery disease. Distribute a copy of Master 2.1, *Three Mysterious Diseases*, to each student and ask four volunteers to read the script to the class.**

   If you have students who are interested and talented in drama, you may want to give them the scripts the previous day and ask them to read them dramatically to the class.

   If students ask what you mean by "unusual cases of disease," explain that it could mean a variety of unexpected occurrences including symptoms that are rare in general, symptoms that are rare in the population in which they are now occurring, or unusual severity of illness or fatality rates.

   You can use the *Mystery Diseases* video on the CD-ROM to introduce the activity if you have the equipment to project the video for the whole class. Follow the instructions on page 31 to load the CD-ROM

into the computer you will use.

3. **Organize students in teams of three and tell them they will spend the next 30 minutes investigating the first mystery disease. Direct them to assign each team member one of the following roles: physician, laboratory scientist, or field researcher. Explain that each of these experts will look for clues that will help his or her team answer the questions the class listed in Step 1.**

   We suggest that you use the same teams as in Activity 1.

4. **Identify stations in the room that have investigation documents for the physicians, laboratory scientists, and field researchers. Distribute one copy each of Master 2.5, *Notes from the Physician's Investigation*; Master 2.6, *Notes from the Laboratory Scientist's Investigation*; and Master 2.7, *Notes from the Field Researcher's Investigation* to each team. Direct students to go to the appropriate station and review and discuss the clues they find there about the disease with their colleague "experts" from the other teams. Ask them to record significant information on the forms you distributed. Tell students they will have 15 to 20 minutes to complete their research.**

   Move among the groups during this time, answering their questions and using probing questions to direct their attention to significant details in their information. Students in the field researcher groups may wonder why there is no Interview Transcript from "J. McDonald." Draw their attention to the "Other Comments" on McDonald's "Investigation of Victim's Home" report, in which she indicates that the victim's mother and aunt refused to be interviewed.

Collect students' *Final Reports* and review them to evaluate how well students were able to identify the evidence that supported or refuted a claim about the disease. Identify areas where students could improve and discuss them with the class when you return their papers.

   Tip from the field test. To save time and reduce confusion, place three or four copies of Masters 2.3, 2.6, and 2.7 at the appropriate stations prior to class time. Then tell students they will find a copy of the form they need to complete at the station.

5. **Reconvene the original teams and distribute one copy of Master 2.8, *Mystery Disease 1 Final Report*, to each student. Allow students 10 minutes to pool their information and complete the report form.**

   Again, move among the groups, answering their questions and directing their attention to significant details. Students may have particular difficulty with the final task, which asks whether the disease is emerging, re-emerging, or endemic. Help them come to the conclusion that this is an emerging disease by asking questions such as "Was there evidence that this disease is common in the Southwest?" "Was there evidence that it was *not* one of these common diseases?" "What did you decide was the cause of the disease?" "Has this infectious agent been known to cause a disease with the ARDS symptoms?" and "What is the evidence that this is an 'old' disease? . . . that it is a 'new' disease?"

6. **Distribute Master 2.9, *Mystery Disease 2 Final Report*, to half the teams and Master 2.10, *Mystery Disease 3 Final Report*, to the remaining half. Explain to students that a group of experts similar to those in their teams pooled information from their investigations to complete these reports. Ask students to study the report forms while you distribute one copy of Master 2.11, *Mystery Diseases Summary Table*, to each student.**

7. **Direct students to complete the table on Master 2.11 for the two diseases for which they have report forms.**

8. **Display a transparency made from Master 2.11, *Mystery Diseases Summary Table*, and ask several teams to report one piece of information as you complete the first row of the table. Ask the remaining teams whether they have additional information and whether they disagree with any of the information provided by the other teams. Follow the same procedure for the other two mystery diseases.**

   All three diseases are classified as emerging diseases and, although students are not given this information, all three have probably occurred for hundreds if not thousands of years. Nevertheless, only recently have cases occurred in sufficient numbers that they were recognized as specific diseases. The infectious agents for the three diseases are transmitted by:

   - Mystery Disease 1—contact with deer mouse (*Peromyscus maniculatus*) urine and feces
   - Mystery Disease 2—bite from deer ticks (*Ixodes dammini* ticks)
   - Mystery Disease 3—contact with rat (*Mastomys natalensis*) urine and feces, and close contact with victims of the disease

   The environmental factors involved are:

   - Mystery Disease 1—climatic conditions favoring large deer mice populations and human encroachment into areas inhabited by deer mice
   - Mystery Disease 2—climatic conditions favoring large acorn harvests and human movement into wooded areas
   - Mystery Disease 3—conditions that reduce competition to *M. natalensis* from *R. rattus*, including human efforts to reduce the *R. rattus* population

9. **Allow students to examine the summary table and then ask them to list any common features they note about the three mystery diseases. Lead a class discussion by asking, "Can you see one overall factor that resulted in the emergence of all three of these diseases?" and "What does this suggest about things people need to consider as we develop land for residential and business purposes?"**

   Common features of the three mystery diseases, as revealed on Master 2.11, are that all the diseases are emerging, the transmission of the infectious agent involves a nonhuman animal, and environmental factors strongly help explain their occurrence. Guide students to the

This is a good time to note how technological advances have improved our ability to identify the infectious agents for mysterious diseases. Identification of the spirochete type of bacterium as the cause of Lyme disease required nearly seven years, whereas molecular biology techniques available in 1993 meant that the infectious agent for HPS was identified within a month. Continuing NIAID-supported research on the Lyme disease spirochete has led to improved diagnosis of the disease and the development of a new vaccine to prevent it.

understanding that environmental and ecological factors, combined with the movement of humans into previously uninhabited areas, help explain the relatively sudden appearance of these "new" diseases.

You may want to reveal the names of the three mystery diseases at this time:

- Mystery Disease 1—hantavirus
- Mystery Disease 2—Lyme disease
- Mystery Disease 3—Lassa fever

Explain to students that these diseases were first recognized in 1993 (HPS), 1975 (Lyme disease), and 1969 (Lassa fever). Although the symptoms and "clues" presented in the mystery disease cases would immediately implicate HPS, Lyme disease, or Lassa fever if physicians saw them today, in 1993, 1975, or 1969, these three diseases were "new" to health care workers, just as they were to students in this activity.

In this step, students are challenged to synthesize in their own words the discussion from Step 9. Completing the sen tences requires them to state and elaborate the activity's major concept.

10. Ask students individually to complete, in writing, the sentences at the bottom of *Mystery Diseases Summary Table*.

11. Collect students' assignments from Step 10 and close the activity by noting several responses (anonymously) and engaging the students in a discussion of the issues that should be considered to avoid or minimize the risks of emerging diseases.

Completing the activity should lead students to recognize that chang ing environmental conditions create opportunities for new or previ ously rare diseases to affect large numbers of people. Students are likely to respond to the second question by a blanket statement such as "People should stay out of uninhabited areas." Challenge them to think more deeply by asking questions such as "Should you or anyone else be allowed to tell people where they can live?" "What if people in a developing country have an opportunity to dramatically increase their income, as well as their country's productivity, by developing an area previously uninhabited by people? Do the advan tages of economic development outweigh the risks of emerging dis eases? What do you need to consider to make this evaluation?" and "How might medical and ecological research efforts help resolve these dilemmas?"

You may want to give students the example of the Aswan Dam in Egypt. Schistosomiasis is a disease that causes diarrhea, abdominal pain, and liver problems. Chronic infections may lead to liver failure and may also affect the central nervous system. The disease is caused by a helminth that has a complex life cycle, including stages in both snails and the human bloodstream. Because snails thrive in still waters such as those found in irrigation canals and artificial lakes, the incidence of schistosomiasis frequently increases following con struction of dams. Although this was known before the Aswan Dam

was constructed, the officials involved in the decision felt that the economic advantages of the dam outweighed the disease conse quences. Before the dam was built, about 1 percent of the school chil dren in the area had schistosomiasis. After the dam was built the incidence of schistosomiasis among children in some villages near the artificial lake rose to 100 percent. Since then, Egypt has spent part of the profits from the Aswan Dam on a major, ongoing chemother apy campaign against schistosomiasis.

This example also shows that the incidence of "old" diseases may be affected by environmental changes. Schistosomiasis is not a "new" dis ease, but the increased incidence of the disease makes it a candidate for a re-emerging disease. Other factors related to disease re-emergence are explored in the next two activities.

PotentialÄ ExtensionsÄ

Several popular books on emerging infectious diseases make exciting reading and provide further illustration of scientists' work in identifying and limiting the risks of emerging diseases. Assign students to read and report on booksÄ such as *The Hot Zone* by Richard Preston (which describes outbreaks of EbolaÄ hemorrhagic fever) and *The Coming Plague* by Laurie Garrett (which describesÄ the efforts of scientists and policymakers regarding a variety of emerging andÄ re-emerging diseases, including HPS, Lassa fever, malaria, and LegionnaireÄ disease). Ä